
DYNAMICS OF SHEARED FLUID-PARTICLE FLOWS : NUMERICAL SIMULATION AT THE GRAIN SCALE

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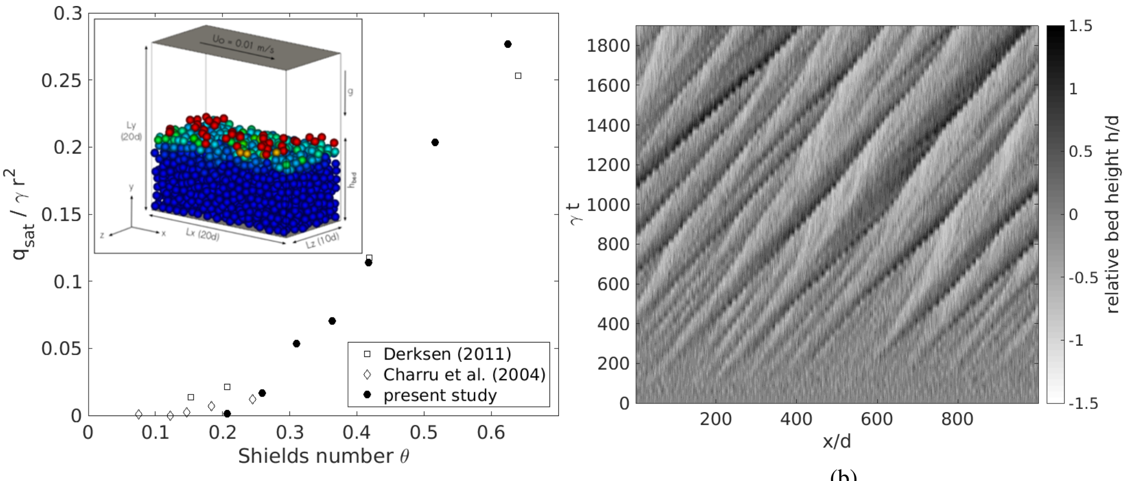
The process of sediment transport by a viscous shear flow over a flat granular bed implies complex mechanisms at different time and spatial scales. In order to describe the evolution of such flows, a better understanding of the influence of local fluid-particle and particle-particle interactions on large scale structures (ripples, dunes[1]) is necessary. For this purpose, local numerical simulations of laminar shear flow eroding a bed of particles were performed. The numerical method used is an Euler-Lagrange model[2], based on the resolution of the Navier-Stokes equations, averaged over cells containing several particles, and Newton's equations for the solid phase using the discrete element method (DEM)[3]. The averaging procedure brings out a solid volume fraction term ε for the fluid phase[4], which mimics the porosity of the effective medium. A fluid-particle interaction term enables a two-way coupling. This method allows us to perform simulations with a large number of particles ($O(10^6)$).

A first set of simulations was performed on relatively small domain ($20d_p \times 20d_p \times 10d_p$) with d_p being the mean diameter of the grains. This size domain allows to reach a steady state, avoiding ripple instabilities. In the present case, the particle Reynolds number $Re_p = 0.48$ and density ratio $\rho_p/\rho_f = 4$ are set constant while the dimensionless shear stress, the Shields number θ, lies in the range [0.1, 0.5]. As observed in Figure 1(a), the variation with θ of the saturated granular flow rate q_{sat}, as obtained from the simulation, is in reasonable agreement with available experimental[5] and numerical[6] data[5, 6], especially for the threshold Shields number $\theta_t \approx 0.12$, which delineates static and moving bed. A second set of simulations was performed on a larger domain ($1000d_p \times 20d_p \times 10d_p$), in order to capture the formation of ripples. Figure 1(b) displays the spatio-temporal evolution of the relative bed height. Ripples clearly grow on the initially flat bed, with a well-defined wavelength. On larger time scales, they tend to merge together, corresponding to the coarsening phenomena observed in the experiments.



(a)

(b)

Figure 1: (a) Dimensionless particle flow rate versus the Shields number θ (inset) computational domain (b) Spatio-temporal evolution of the relative bed height

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